

CONTRIBUTIONS FROM THE LABORATORY OF THE UNIVERSITY OF  
PENNSYLVANIA.

## No. XI.

*On some Tellurium and Vanadium Minerals.*

BY F. A. GENTH.

*(Read before the American Philosophical Society, August 17th, 1877.)*

Since the publication of my papers: "On American Tellurium and Bismuth Minerals," read before the American Philosophical Society, August 21, 1874, and "On Some American Vanadium Minerals," published in the American Journal of Science and Arts, July, 1876, I have made several observations which I believe to be worthy of being placed upon record.

## 1. NATIVE TELLURIUM.

Its occurrence at the Red Cloud Mine, where it is a comparatively rare mineral, has previously been mentioned. Recent developments in Colorado have furnished a number of new localities, in some of which it is found in considerable quantities and in peculiar varieties, associated with other very interesting minerals.

1. In Magnolia District, Boulder County, at the Keystone Mine and Mountain Lion Mine (which are working the same vein), also at the Dun Raven Mine, it occurs in crystals and crystalline masses. The crystals are usually small and very indistinct, much distorted, cavernous, and the prismatic planes longitudinally, deeply striated; often surrounding quartz crystals; occasionally, besides the planes of the hexagonal prism, rhombohedral and basal planes can be observed; it is also found in columnar masses and, disseminated in grains, through other minerals.

Sometimes it forms sheets and thin plates between the ores, which consist of quartz, mixed with a peculiar greenish vanadiferous mineral (? roscoelite), coloradoite, calaverite, pyrite, &c. This variety has often the appearance of "slickensides," and is sometimes in masses as thin as paper, occasionally, however  $\frac{1}{2}$  of an inch in thickness; it is dark grey, on a fresh fracture greyish white; it is finely granular and of very little lustre. The specific gravity of the pure mineral (making allowance for the admixed quartz) was found to be 6.275.

The analysis gave, after deducting 8.90% of quartz, as follows:

Au	=	0.60
Ag	=	0.07
Te	=	96.91
V <sub>2</sub> O <sub>3</sub>	=	0.49
FeO	=	0.78
Hg, Al <sub>2</sub> O <sub>3</sub> , MgO } K <sub>2</sub> O, &c. }	=	1.15
		<hr/>
		100.00

2. A very peculiar variety of native tellurium occurs at the Mountain Lion Mine, where it is associated with quartz and imbedded in a greenish, clayey mineral. It has been discovered by Mr. Theodore Berdell, of Boulder, Colorado, who very kindly furnished me with this and most of the other specimens from this mine.

He distinguished it as "lionite." It occurs in flat, plate-like masses of  $\frac{1}{8}$  to  $\frac{3}{16}$  of an inch in thickness; it has a dark grey color, very little lustre, and a somewhat columnar structure at right angles with the plates; brittle.  $H = 3$ ; Sp. Gr. = 4.005.

Examined with a strong magnifying glass it shows numerous air-holes, but otherwise seems to be quite uniform. It looks very much as if it had been melted and not unlike a "matte." The analyses showed an admixture of a very large quantity of silicic acid and silicates, and it is impossible to conceive, how such heterogeneous substances could have formed such a uniform material. It can, of course, not be considered as a species, but only as a variety of native tellurium. The analyses gave:

		I.	II.
Au	=	1.38	1.53
Ag	=	0.25	0.25
Te	=	55.86	55.54
SiO <sub>2</sub>	=	34.72	35.91
Al <sub>2</sub> O <sub>3</sub>	}	6.15	6.14
Fe <sub>2</sub> O <sub>3</sub>			
MgO	=	0.17	0.19
CaO	=	0.48	0.26
		<hr/>	<hr/>
		99.01	99.82

3. Very minute, but brilliant, crystals of native tellurium, in combinations of an hexagonal prism and pyramid have been found in cavities of quartz at the Smuggler Mine, Ballerat District, Boulder County, Colorado. They are mostly distorted and have the appearance of rhombic prisms, from the enlargement of two opposite hexagonal planes at the expense of the four others. The hexagonal planes are deeply striated, and the pyramidal ones rarely well developed. The ore from the deeper part of the vein consists largely of native tellurium in a granular variety, associated with sylvanite, coloradoite, &c. The analyses of it, after deducting in the first 28.04% of quartz, and in the second 65.21% of quartz, gave:

		I.	II.
Au	=	3.40	2.18
Ag	=	1.69	1.15
Hg	=	1.07	1.34
Cu	=	0.51	0.43
Pb	=	0.74	1.02
Fe	=	0.12	0.18
MgO	=	0.12	0.06
Te	=	92.29	[93.64] by diff.
		<hr/>	<hr/>
		99.94	100.00

4. The largest quantities of native tellurium have been observed at the John Jay Mine, in Central District, Boulder County, Colorado. I was informed that masses of 25 pounds in weight had been found there. I am indebted to the owner, Mr. A. J. Van Deren, for very fine specimens, which were taken from his mine at a depth of 30 to 35 feet.

The tellurium is more or less mixed with quartz, it is granular to columnar in structure and of a color between tin-white and lead-grey. In the cavities and on the surface are rarely found tellurous oxide or tellurite, in minute crystals.

A very pure specimen, after the deduction of 14.08% of quartz, contained :

Au	=	1.04
Ag	=	0.20
Zn	=	0.32
Fe	=	0.89
Te	=	97.94
		<hr/>
		100.39

## 2. HESSITE.

My friend, Mr. August Raht, wrote me from Utah on the 20th February, 1877, that, in testing an ore from the Kearsage Mine, Dry Cañon, Utah, he found it to contain large quantities of tellurium, and afterwards, in analyzing a pure piece before the blow-pipe, obtained :

Ag	=	58.790
Au	=	0.103

It is evidently hessite, almost free from gold, similar to that which I described from the Red Cloud Mine, Colorado, where it has been *once* found as a very great rarity.

## 3. COLORADOITE, A NEW MINERAL.

I have mentioned the occurrence of telluride of mercury, which I have called "coloradoite" already at the meeting of the American Philosophical Society of October 20th, 1876. I observed it amongst ores from the Keystone Mine, Magnolia District, received for examination by the late Dr. W. H. Wenrich, of Denver. It also occurs at the Mountain Lion Mine; a specimen of ore, for which I am indebted to Commodore Stephen Decatur, Centennial Commissioner of Colorado, and which was found at the depth of 8 or 10 feet at the Smuggler Mine, Ballerat District, proved also to be this interesting species.

Not crystallized, without cleavage; massive, somewhat granular; that from the Smuggler inclining to an imperfectly columnar structure. Fracture uneven to subconchoidal. Hardness about 3; Sp. Gr. = 8.627—(pure mineral, after making allowance for the admixture of native tellurium and quartz). Lustre metallic; color iron-black, inclining to grey,

with a very faint purplish hue; frequently tarnished with purplish, blue and green colors.

B. B. in a tube slightly decrepitates, fuses and yields an abundant sublimate of metallic mercury, also drops of tellurous oxide and, next to the assay, metallic tellurium. On charcoal it gives a greenish flame and white sublimate. Soluble in nitric acid. Very rare. At the Keystone and Mountain Lion Mines, associated with native tellurium and quartz; at the Smuggler Mine it is often mixed with native gold, resulting from sylvanite, more or less completely decomposed, native tellurium and tellurite. It is probable that the admixture of sylvanite produces its columnar structure.

I have endeavored by mechanical means to separate, as much as possible, the pure coloradoite from the associated minerals, but was not successful.

The best selected fragments from the Smuggler were first digested for some time with ammoniac hydrate to remove the tellurite; the remaining impurities are gold, sylvanite and quartz.

The analyses of the heaviest portions from the Keystone Mine, which have been obtained by levigation, show a higher percentage of mercury, the lighter a larger admixture of tellurium. The results leave no doubt that the pure coloradoite has the composition: Hg Te, corresponding with that of Cinnabar and Tiemannite, and containing:

Hg	=	60.98
Te	=	39.02

The specimens from the Keystone Mine, after deducting quartz and gold, gave the following results:

	I.	II.	III.	IV.	V.
Quartz and Gold	= [28.50]	— [46.83]	— [25.18]	— [8.46]	— [20.72]
Hg	= 56.33	— 52.28	— 51.48	— 49.80	— 45.63
Te	= 43.81	— 42.95	— 44.25	— 46.74	— 50.05
Al <sub>2</sub> O <sub>3</sub> , Fe <sub>2</sub> O <sub>3</sub>	} = traces	= 2.44	} not determined.		
V <sub>2</sub> O <sub>3</sub>		= 0.70			
MgO		= 0.11			
CaO		= 0.84			
K <sub>2</sub> O, Na <sub>2</sub> O					
	100.14	99.32			

SMUGGLER MINE.

	VI.	VII.
Quartz	= [2.90]	— [3.05]
Au	= 3.46	— 7.67
Ag	= 2.42	— 7.18
Hg	= 55.80	— 48.74
Cu	= trace	— 0.16

SMUGGLER MINE—*Continued.*

		VI.		VII.
Zn	=	trace	—	0.50
Fe	=	1.35	—	0.92
Te	=	36.24	—	34.49
		<hr/>		<hr/>
		99.27		99.66

I.	Contains	92.38 %	coloradoite	and	7.76 %	native tellurium.
II.	"	85.74 "	"	"	9.49 "	"
III.	"	84.43 "	"	"	11.30 "	"
IV.	"	81.67 "	"	"	14.87 "	"
V.	"	74.83 "	"	"	20.85 "	"
VI.	"	91.51 "	"			
VII.	"	79.93 "	"			

When I first received the mineral from the Smuggler, the preliminary examination of it made me think that gold and silver might be essential constituents of the same; the subsequent analyses showed them to be admixtures. The specimen which furnished the material for investigation, having come from near the surface, contained such a quantity of tellurite, that I was anxious to analyze the ore from the undecomposed part of the vein, and, for this reason, delayed the publication of my results for over six months. After a great deal of trouble, I secured a specimen, but unfortunately, it proved to be almost pure native tellurium (of which I gave the analyses above), I. containing an admixture of only 1.75%, and II. of 2.20% of coloradoite.

## 4. CALAVERITE.

I established this species nine years ago, on very minute quantities found, associated with petzite, at the Stanislaus Mine, Calaveras County, California; then I observed it again as a great rarity at the Red Cloud, and published an analysis made with only 0.1654 grammes. From Mr. Berdell I received a short time ago a specimen, which furnished me with more than five grammes of calaverite, mixed only with a small quantity of quartz and coated with ? roscoelite. A reëxamination of this rare species was therefore highly desirable.

In very minute, imperfect crystals, resembling rhombic or monoclinic forms, but too indistinct for a more exact determination; cleavage indistinct; massive granular; fracture uneven.

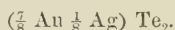
H = 2.5; Sp. Gr. (of the pure mineral, less quartz), = 9.043. Pale bronze yellow; brittle. In thin seams and disseminated in quartz and gangue-rock at the Keystone and Mountain Lion Mines.

The analyses gave, after deducting in I. 4.96% of quartz, and in II. 4.00% of quartz :

	I.	II.	Calculated.
Au	= 38.75	— 38.91	— 39.01
Ag	= 3.03	— 3.08	— 3.06
Te	= 57.32	—	— 57.93
V <sub>2</sub> O <sub>3</sub>	= 0.05	—	
FeO	= 0.30	—	
Al <sub>2</sub> O <sub>3</sub> , MgO, &c., } not det'd.	= 0.55	—	
	100.00		100.00

These analyses give the ratios of (Au Ag) : Te = 1 : 2; Au : Ag = 7 : 1.

The composition of calaverite, corresponding with the above analyses, is therefore :



In "Nature," of March 8th, 1877, it is stated that at the February meeting of the Hungarian Geological Society, Professor Krenner announced the discovery at Nagy-Ag, in Transylvania, of a pure *Telluride of gold*, in a crystalline state, which he calls "bunsenite" (a name already given by Prof. J. D. Dana, in 1868, to the niccolous oxide from Johannegeorgenstadt, described by Bergemann). As I have no access to the original publication, I am unable to decide whether it is different from calaverite; perhaps it is a variety even more free from silver than those of this country.

### 5. TELLURITE.

Already in 1842, Petz observed tellurous oxide, associated with native tellurium at Facebay and Zalathna in Transylvania. It has never been observed from any other locality, until I have lately noticed it with tellurium at the Keystone and Smuggler Mines, but especially in cavities and fissures of the native tellurium of the John Jay Mine, where it is found in minute white, yellowish-white and yellow crystals, mostly prismatic, often longitudinally striated, isolated or aggregated into bundles; a few of the white crystals are acute rhombic pyramids. Cleavage eminent in one direction.

Lustre vitreous inclining to resinous, on the cleavage plane adamantine.

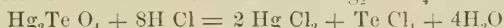
Readily soluble in ammoniac hydrate; the solution contains only tellurite of ammonium; the composition of tellurite is therefore, as Petz had already suggested, tellurous oxide = TeO<sub>2</sub>.

### 6. MAGNOLITE, A NEW MINERAL.

This highly interesting mineral is the product of the oxydation of coloradoite. It occurs very rarely with native mercury in the upper, decomposed part of the Keystone Mine, associated with quartz, limonite and psilomelané.

In exceedingly fine needles, which under the microscope appear in bundles or tufts, sometimes radiating; some of the groups seem to have crystallized around a globule of mercury, which latter, in breaking the specimen, has fallen out, leaving a round empty space in the centre of the crystals. Color white; lustre silky.

Readily soluble in *very dilute* nitric acid, the solution yielding a precipitate of Hg Cl by hydrochloric acid; the mineral is also soluble in hydrochloric acid, the solution contains Hg Cl<sub>2</sub> and Te Cl<sub>4</sub>, which proves that its composition is "mercurous tellurate" = Hg<sub>2</sub> Te O<sub>4</sub>. —



The mineral is also blackened by ammoniac hydrate.

Name after "Magnolia" District.

#### 7. FERROTELLURITE, A NEW MINERAL.

A crystalline coating upon quartz, associated with native tellurium. Under the microscope it appears in very delicate tufts, sometimes radiating or, when in cavities, as very minute prismatic crystals of a color between straw and lemon-yellow inclining to greenish-yellow.

Insoluble in ammoniac hydrate; some of the mineral, which had been treated with ammoniac hydrate for the purpose of removing the tellurous oxide present, was dissolved in hydrochloric acid. The solution contained tellurous oxide, ferric oxide, and a trace of niccolous oxide; the mineral is therefore probably a ferrous tellurate = FeTeO<sub>4</sub>, hence the name. The quantity at hand is too small for a fuller investigation.

It occurs at the Keystone Mine, Magnolia District, Colorado, associated with native tellurium, tellurite, and a peculiar iron sulphide, in which a part of the sulphur is replaced by tellurium. A preliminary examination of it gave Fe = 41.01, Ni = 0.72, Te = 4.06 and S = 41.73 = 87.52. The material for analysis was slightly oxidized, but the difference of 12.48 % is too great to be covered by this. I shall repeat the analysis, if ever I should succeed to get this mineral again.

#### 8. ROSCOELITE.

It will be remembered, that almost simultaneously, Prof. H. E. Roscoe and I investigated the mineral, which now bears his name, his paper having been received by Royal Society on May 10th, 1876, (Proc. Royal Soc. XXV, 109.) whilst mine was written and sent to the editors of the American Journal of Science on May 16th, 1876.

I regret to say that in some of the essential points our results do not agree.

From the nature of the material and the information received from Dr. James Blake of San Francisco, no doubt can exist that, that, which he had sent to me, was as good and pure as it could be obtained. In my examination (Am. Journ. of Sc. [3] XII, 32) I showed that even the apparently purest scales, selected with the greatest pains, were not altogether free from admixtures. With the greatest difficulty I obtained enough of almost

pure scales (containing only 0.85 % of quartz, gold, &c.) to make *one* analysis, which, as it was made with the greatest care, must be a very close approximation of the truth. The material of the other analyses was far more contaminated, and the results were given merely for comparison and to show the influence of the admixtures upon the analyses.

From Prof. Roscoe's analyses it does not appear that he attempted to separate the impurities by chemical means, and thus he gives the composition of the whole mixture.

He assumes the vanadium to be present as pentoxide, the iron as ferric oxide, the manganese as manganic oxide, the two latter as replacing alumina; and magnesia, lime and soda as replacing potassium oxide.

As I have made a direct determination of the state of oxydation of the vanadium, I can say *positively* that, if any, only the smaller portion of the vanadium is pentoxide. I found the composition of the vanadium oxide to be  $V_6O_{11} = 2 V_2O_3, V_2O_5$ ; but as it was obtained after allowing for the oxydation of ferrous into ferric oxide, and as the quantities of ferrous oxide have been found to vary from 1.67 to 3.30 %, it is not impossible that an insufficient quantity of oxygen has been deducted, and that the whole of the vanadium is present as  $V_2O_3$ .

Pure roscoelite contains no manganese; in Prof. Roscoe's analyses 0.85 — 1.45 % of manganic oxide have been found, which confirms my opinion that his material was not pure; but what is most astonishing to me is the very low per centage of silica which he finds.

From his analyses he calculates a formula, and from this the per centage composition, which, however, is far from corresponding with his analyses, as for instance:

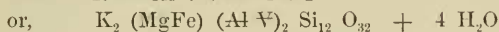
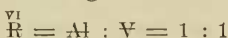
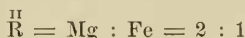
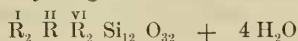
Silica found	= 41.25,	calculated = 41.18
Potassium oxide found	= 8.56,	" = 14.24

I had not calculated any formula from my analyses, being in hope that I may yet be able to procure this interesting mineral in a still purer state for further investigation. For comparison I will insert my analysis (*a*) which certainly closely represents the true composition of Roscoelite, and will add the formula corresponding with the same, with this alteration however, that I consider all the vanadium as  $V_2O_3$ . It contains, after deducting 0.85 % of quartz, gold, &c.:

	Found.	Calculated.
SiO <sub>2</sub>	= 47.69	— 49.33
Al <sub>2</sub> O <sub>3</sub>	= 14.10	— 14.09
V <sub>2</sub> O <sub>3</sub>	= 20.56	— 20.62
FeO	= 1.67	— 1.64
MgO	= 2.00	— 1.83
Li <sub>2</sub> O	= trace.	—
Na <sub>2</sub> O	= 0.19	—
K <sub>2</sub> O	= 7.59	— 7.55
Ignition	= 4.96	— 4.94
	<hr/> 98.76	<hr/> 100.00



The analysis agrees with the formula :



as will be seen from the calculated per centage.

#### GREEN MINERAL FROM COLORADO, ? ROSCOELITE.

A mineral which is closely allied to, and which may be only a variety of roscelite, occurs in Magnolia District, Boulder County, Colorado, especially at the Keystone and Mountain Lion Mines. It has not yet been found in a pure state, but only as the coloring matter of quartz which, at some parts of these mines, forms the gangue rock of the veins. The purest, which I have seen, was in the form of a thin, earthy coating of a greyish-green to olive-green color upon calaverite.

Mr. Theodore Berdell, to whom I am indebted for specimens has repeatedly called my attention to this green quartz, and mentioned that it is always very rich in precious metals.

For the examination of the green mineral, which colors the quartz, about 150 grammes of the latter were powdered and separated from the metallic particles by levigation, as near as possible.

The metallic particles were found to be a mixture of native tellurium and calaverite, containing :

Native tellurium	=	55.4 %
Calaverite	=	38.5 "

The green quartz, which was left, was found on an average of four experiments to contain :

Quartz	=	79.38 %
Tellurium	=	1.05 "
Gold	=	0.03 "
		80.46 %

This leaves for the "green mineral" about 19.5 % which was adopted as the basis for calculation of the results of the analyses.

In two experiments, made for the purpose of ascertaining the state of oxydation of the vanadium, it was found that after making due allowance for the oxydation of ferrous into ferric oxide by potassium permanganate, the oxygen in the vanadium pentoxide to that of the vanadium oxide in the mineral was : 5 : 3 and 5 : 2.88, which leaves no doubt that the vanadium was present as  $V_2O_3$ .

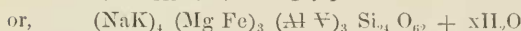
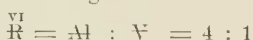
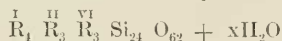
The water, which was present in small quantity, could not be determined with accuracy, because, on ignition, a portion of the tellurium went

off as hydrogen telluride. In one experiment with the mixture of quartz and green mineral 1.24% was found, in a second 0.75—*both are too high.*

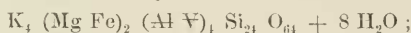
The following are the results of the analyses of the green mineral, after deducting quartz, &c.:

	I.	II.	III.	IV.	V.	Av'ge.
SiO <sub>2</sub> =	57.15	55.77	—	57.31	—	56.74
Al <sub>2</sub> O <sub>3</sub> =	19.94	—	—	19.46	19.46	19.62
V <sub>2</sub> O <sub>3</sub> =	8.44	—	7.37	7.79	7.51	7.78
MnO =	trace	—	—	—	—	trace
FeO =	3.51	—	4.52	—	3.51	3.84
MgO =	2.87	—	2.49	2.52	—	2.63
Li <sub>2</sub> O =	trace	—	—	—	—	trace
Na <sub>2</sub> O =	0.94	—	—	—	—	0.94
K <sub>2</sub> O =	8.11	—	—	—	—	8.11
H <sub>2</sub> O =	not det.	—	—	—	—	not det
	100.96					99.66

The formula which corresponds nearest to the average analysis is :



Doubling, for the sake of comparison, the formula of roscobelite we have:



this seems to prove that the green mineral accompanying the tellurium ores of the Keystone and Mountain Lion Mines is, although it may be a new species, is more probably a *variety of roscobelite*, in which a *great portion of the vanadium is replaced by aluminium.*

#### 9. VOLBORTHITE.

The Siberian volborthite has never been analyzed.

Having observed in an experiment which I made with a few fragments from Woskressenskoi, in the Government Perm, in Ural, received from my friend, Prof. Geo. J. Brush, the presence of barium, I communicated this result to him, when he immediately, with his usual great liberality and kindness, placed at my disposal for a fuller investigation, all he had. I give the results, imperfect as they may be, because they may induce others, who have better material for investigation, to repeat the analyses.

The mineral occurred as a crystalline coating on the grains and pebbles of quartz, and in the cavities of an argillaceous conglomerate; it appeared to be very pure, of a siskingreen to a greenish yellow color, and of a pearly lustre.

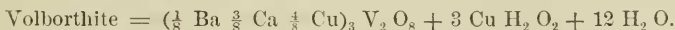
As it was an impossibility to pick out the volborthite, the whole mass was crushed, merely to separate the grains of the conglomerate. These being very little acted upon, the mixture was treated with *very dilute* nitric acid, which dissolved the vanadate, and left the bulk of the conglomerate almost untouched; the latter was thrown on a tared filter, washed, dried and weighed. The amount of water in it was afterwards determined by ignition. In a separate portion of the mixture the total amount of water was also determined.

Different quantities gave 81.49 and 88.43% of insoluble residue, with 2.18 and 2.15 water. The total water was found in one sample to be 6.30%, and the ignited insoluble residue 83.74%, which would give for the *not* ignited residue 85.55%, and 14.45 soluble substances with 4.49 water or, 31.09%, which is a close approximation to the real quantity in the soluble portion.

The results of the analyses of the soluble portion, to which I add the calculated percentage of volborthite corresponding to the formula given below, are as follows :

	I.	II.	Calculated.
Si <sub>2</sub> O <sub>2</sub>	= 1.38	— 1.36	—
Al <sub>2</sub> O <sub>3</sub>	= 4.45	— 4.78	—
Fe <sub>2</sub> O <sub>3</sub>	= 1.77	— 0.45	—
MgO	= 3.01	— 1.42	—
CuO	= 34.04	— 38.01	— 38.41
CaO	= 4.29	— 4.49	— 6.77
BaO	= 4.29	— 4.30	— 6.17
V <sub>2</sub> O <sub>5</sub>	= 13.62	— 13.59	— 19.63
H <sub>2</sub> O (by diff.)	= [33.15]	— [31.60]	— 29.02
	100.00	100.00	100.00

Considering silica, alumina, ferric oxide, magnesia and a portion of the water as impurities, and assuming the Woskressenskoï volborthite to be a combination of vanadates of barium, calcium and copper, with hydrate of copper and water of crystallization, we arrive at the following formula, closely agreeing with the analyses :



It will be seen that volborthite is closely allied to psittacinite (Am. Journ. Sc. [3] XII., 36), the formula of which I give for comparison :



the difference being that the latter mineral contains twice as much  $\text{R}_3 \text{V}_2 \text{O}_8$  and half as much water of crystallization; and lead in the place of barium, calcium, and a portion of the copper.

UNIVERSITY OF PENNSYLVANIA,

PHILADELPHIA, August 1st, 1877.